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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/069,364	02/25/2002	Danyang Liu		1513

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EXAMINER	
BARNES, CRYSTAL J	

ART UNIT	PAPER NUMBER
2121	3

DATE MAILED: 11/13/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

9

Office Action Summary	Application No.	Applicant(s)	
	10/069,364	LIU ET AL.	
	Examiner	Art Unit	
	Crystal J. Barnes	2121	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *25 February 2002* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-15* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-15* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Claim Rejections - 35 USC § 112

1. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

2. Claims 13 and 15 are rejected under 35 U.S.C. 112, first paragraph, because the specification, while being enabling for a multiple-input multiple-output (MIMO) controller, does not reasonably provide enablement for any PID controller or linear controller. The specification does not enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the invention commensurate in scope with these claims. This invention relates to the design of the structure of a multivariable PID controller (see Technical Field of the Invention). The applicant also discloses in this invention, the SISO PID controller is extended to the MIMO PID controller (see Detailed Description of the Invention). The applicant fails to teach obtaining PID parameters or tuning constants of any PID controller or linear controller. The applicant only discloses the structure of the SISO/MIMO controller. No enablement for any PID controller or linear controller is provided.

3. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Claims 7-12 and 15 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

5. Claims 7-12 and 15 recite the limitation "PID controller" in the first line of the claims. There is insufficient antecedent basis for this limitation in the claim.

6. Regarding claim 4, the phrase "for example" and the term "etc." renders the claim indefinite because it is unclear whether the limitation(s) following the phrase are part of the claimed invention. See MPEP § 2173.05(d).

7. Claims 13 and 14 are rejected under 35 U.S.C. 112, second paragraph, as being incomplete for omitting essential elements, such omission amounting to a gap between the elements. See MPEP § 2172.01. The omitted elements are: the structure of a PID controller or a linear controller.

8. Claims 13 and 14 are rejected as failing to define the invention in the manner required by 35 U.S.C. 112, second paragraph.

The claim(s) are narrative in form and replete with indefinite and functional or operational language. The structure which goes to make up the device must be

clearly and positively specified. The structure must be organized and correlated in such a manner as to present a complete operative device. The claim(s) must be in one sentence form only. Note the format of the claims in the patent(s) cited.

Claim Rejections - 35 USC § 102

9. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless -
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

10. Claims 1, 2, 4, 5, 7, 8, 10, 11 and 13 are rejected under 35 U.S.C. 102(b) as being anticipated by USPN 4,563,734 Mori et al.

As per claim 1, the Mori et al. reference discloses MIMO (multiple-input multiple-output) PID controller which has an n-dimensional process variable vector PV (see column 2 lines 29-32, "plurality of control variables (process inputs)") with the n process variables PV1, PV2, ..., and PVn being its first, second, ... , and n-th component; an n-dimensional set point vector SP (see column 2 lines 43-46, "set-point signal") with the n set points SP1, SP2, ... , and SPn being its first, second, ... ,

and n-th component; and an m-dimensional controller output vector CO (see column 2 lines 29-32, "plurality of controlled variables (process outputs)") with the m controller outputs CO1, CO2, ... , and COm being its first, second, ... , and m-th component; where m and n are positive integers (see column 2 lines 36-40, "any positive integer not less than 2"), and in which the PID control equation is CO(k) = CO(k-1) + K1*SP(k)*T + K1*a(k,1) + K2*a(k,2) + ... + Kj*a(k,j), where k is the discrete time (see column 2 lines 47-48, "discrete-time control error signal"), T is the sampling period (see column 2 line 50, "sampling period"), j is a positive integer (see column 2 lines 36-40, "any positive integer not less than 2"), K1, K2, ... , Kj are m by n PID parameters (see column 2 lines 51-55, "digital PID parameters"), a(k,1) = |-PV(k)|*T, and a(k,j) = |a(k,j-1) - a(k-1,j-1)|/T for j > or = 2 (see figure 3 and columns 3-4 lines 62-24, "... discrete-time model of the MIMO process ... N-dimensional vector in the process output ... N- dimensional vector in the process input ...").

As per claim 2, the Mori et al. reference discloses the m by n PID parameters K1, K2, ... , and Kj are obtained by using an optimization algorithm which minimizes the largest modulus of all poles of the discrete time closed loop transfer function from said SP to said PV (see column 5 lines 66-67, "... PID control

parameters are obtained from the S transfer function ..."; see column 8 lines 9-13, "... PID parameters ... are tuned in accordance with the identified transfer function"; see column 8 lines 60-62).

As per claim 4, the Mori et al. reference discloses some or all of the terms K2*a(k,2), K3*a(k,3), ... , and Kj*a(k,j) that appear on the right-hand side of the PID control equation are removed (see column 10 lines 45-50, "... PI operations ... PID operation ").

As per claim 5, the rejection of claim 2 is incorporated and further claim 5 contains limitations recited in claim 2; therefore claim 5 is rejected under the same rationale as claim 2.

As per claim 7, the Mori et al. et al. reference discloses said PV (process inputs), said SP (set-points), said CO (process outputs), and said PID parameters (PID parameters) are all scalars, and m=n=1 (see columns 3-4 lines 62-24, "... discrete-time model of the MIMO process ... N-dimensional vector in the process output ... N- dimensional vector in the process input ..."; see column 6 lines 2-8; see columns 11-12 lines 46-3).

As per claim 8, the rejection of claim 7 is incorporated and further claim 8 contains limitations recited in claim 7; therefore claim 8 is rejected under the same rationale as claim 7.

As per claim 10, the rejection of claim 7 is incorporated and further claim 8 contains limitations recited in claim 7; therefore claim 8 is rejected under the same rationale as claim 7.

As per claim 11, the rejection of claim 7 is incorporated and further claim 8 contains limitations recited in claim 7; therefore claim 8 is rejected under the same rationale as claim 7.

As per claim 13, the rejection of claim 2 is incorporated and further claim 13 contains limitations recited in claim 2; therefore claim 13 is rejected under the same rationale as claim 2.

Claim Rejections - 35 USC § 103

11. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which

said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

12. Claims 1, 4, 7 and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over M. R. Katebi et al., "Controller Tuning Methods for Industrial Boilers", 26th Annual Conference of the IEEE Industrial Electronics Society, Vol. 2, 22-28 Oct. 2000, pp. 1457-1462 in view of logical reasoning.

As per claim 1, the M. R. Katebi et al. reference discloses MIMO (multiple-input multiple-output) PID controller which has an n-dimensional process variable vector PV with the n process variables PV1, PV2, ..., and PVn being its first, second, ... , and n-th component; an n-dimensional set point vector SP with the n set points SP1, SP2, ... , and SPn being its first, second, ... , and n-th component; and an m-dimensional controller output vector *CO* with the m controller outputs *CO*1, *CO*2, ... , and *CO*m being its first, second, ... , and m-th component; where m and n are positive integers, and in which the PID control equation is *CO*(k) = *CO*(k-1) + K1*SP(k)*T + K1*a(k,1) + K2*a(k,2) + ... + Kj*a(k,j), where k is the discrete time, T is the sampling period, j is a positive integer, K1, K2, ... , Kj are m by n PID parameters, a(k,1) = |-PV(k)|*T, and a(k,j) = |a(k,j-1) - a(k-1,j-1)|/T for j > or = 2;

(see page 1457 Introduction section, "... variables of a given sub-process. ... local controller set points. ... system variables at desired values ... Boilers have multiple numbers of inputs and outputs.")

(see page 1459 Optimal Control Based Methods sub-section, "... a multi-objective optimization method to calculate the parameters of the PID controller. ... an optimal procedure for selecting the PID parameters of a multi-loop controller.")

(see page 1460, Non Parametric Methods section, "... controlled variables are measurable, the classes of input disturbances and reference inputs are known, and the system is controllable by a diagonal PID controller.")

(see page 1460 Davison Method sub-section, "... tuning matrices for a multivariable controller ... closed-loop system ...")

(see page 1460 Generalized Ziegler-Nichols Method sub-section, "... proposed an extension of SISO ... to MIMO system.")

The M. R. Katebi et al. reference does not expressly disclose the PID control equation of the present invention.

However, it would have been logically to one of ordinary skill in the art to derive various equations depending on numbers of inputs and plant parameters to calculate PID gain parameters.

At the time the invention was made, it would have been obvious to a person of ordinary skill in the art to modify the structure (equation) of the PID controller by deriving other equations to calculate PID gain parameters.

One of ordinary skill in the art would have been motivated to formulate other equations just as long as tuning of the PID controllers was performed.

As per claim 4, the rejection of claim 1 is incorporated and further claim 4 contains limitations recited in claim 1; therefore claim 4 is rejected under the same rationale as claim 1.

As per claim 7, the M. R. Katebi et al. reference discloses said PV, said SP, said CO, and said PID parameters are all scalars, and m=n=1 (see page 1458 Nominal Performance and Robust Stability sub-sections).

As per claim 10, the rejection of claim 7 is incorporated and further claim 10 contains limitations recited in claim 7; therefore claim 10 is rejected under the same rationale as claim 7.

13. Claims 2, 5, 8, 11 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over M. R. Katebi et al., "Controller Tuning Methods for Industrial Boilers", 26th Annual Conference of the IEEE Industrial Electronics Society, Vol. 2, 22-28 Oct. 2000, pp. 1457-1462 in view of Toru Yamamoto et al., "Generalized Minimum Variance Self-Tuning Pole-Assignment Controller with a PID Structure", Proceedings of the 1999 IEEE International Conference on Control Applications, Vol. 1, 22-27 Aug. 1999, Pages 125 -130.

As per claim 2, the M. R. Katebi et al. reference does not expressly disclose the m by n PID parameters K1, K2, ... , and Kj are obtained by using an optimization algorithm which minimizes the largest modulus of all poles of the discrete time closed loop transfer function from said SP to said PV.

The Toru Yamamoto et al. reference discloses

(see page 126 PID controller design, "The tuning of the control parameters in PID control laws ... a self-tuning PID control algorithm based on the generalized minimum variance control scheme ...")

(see page 126 PID tuning, "... closed-loop input-output relationship ...")

At the time the invention was made, it would have been obvious to a person of ordinary skill in the art to modify the controller tuning method taught by the M.

R. Katebi reference with the self-tuning PID algorithm taught by the Toru Yamamoto et al. reference.

One of ordinary skill in the art would have been motivated to modify the PID tuning algorithm to illustrate poles and a closed loop transfer function.

As per claim 5, the rejection of claim 2 is incorporated and further claim 5 contains limitations recited in claim 2; therefore claim 5 is rejected under the same rationale as claim 2.

As per claim 8, the M. R. Katebi et al. reference discloses said PV, said SP, said CO, and said PID parameters are all scalars, and m=n=1 (see page 1458 Nominal Performance and Robust Stability sub-sections).

As per claim 11, the rejection of claim 8 is incorporated and further claim 11 contains limitations recited in claim 8; therefore claim 11 is rejected under the same rationale as claim 8.

As per claim 13, the rejection of claim 2 is incorporated and further claim 13 contains limitations recited in claim 2; therefore claim 13 is rejected under the same rationale as claim 2.

14. Claims 3, 6, 9, 12, 14 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over M. R. Katebi et al., "Controller Tuning Methods for Industrial Boilers", 26th Annual Conference of the IEEE Industrial Electronics Society, Vol. 2, 22-28 Oct. 2000, pp. 1457-1462 in view of Toru Yamamoto et al., "Generalized Minimum Variance Self-Tuning Pole-Assignment Controller with a PID Structure", Proceedings of the 1999 IEEE International Conference on Control Applications, Vol. 1, 22-27 Aug. 1999, Pages 125 -130, and further in view of G. Celentano et al., "Computer Aided Design of Decentralized PID Controllers", International Conference on Control, 13-15 April 1988, Page(s): 6 -9.

As per claim 3, the modified teachings of Katebi et al. and Yamamoto et al. do not expressly disclose said optimization algorithm is a constrained optimization algorithm which minimizes the largest modulus of all poles of the discrete time closed loop transfer function from said SP to said PV and at the same time guarantees that the user prescribed constraints on the PID parameters are satisfied.

The G. Celentano et al. reference discloses

(see page 8 Remark 6, "... minimize the greatest closed loop time constant imposing constraints not only on controller parameters but also on overshoot and control signals amplitude ...")

At the time the invention was made, it would have been obvious to a person of ordinary skill in the art to further modify the modified controller tuning method with the design algorithm taught by the G. Celentano et al.

One of ordinary skill in the art would have been motivated to further modify the tuning algorithm to incorporate constraints to improve the tuning algorithm.

As per claim 6, the rejection of claim 3 is incorporated and further claim 6 contains limitations recited in claim 3; therefore claim 6 is rejected under the same rationale as claim 3.

As per claim 9, the M. R. Katebi et al. reference discloses said PV, said SP, said CO, and said PID parameters are all scalars, and m=n=1 (see page 1458 Nominal Performance and Robust Stability sub-sections).

As per claim 12, the rejection of claim 9 is incorporated and further claim 12 contains limitations recited in claim 9; therefore claim 12 is rejected under the same rationale as claim 9.

As per claim 14, the rejection of claim 3 is incorporated and further claim 14 contains limitations recited in claim 3; therefore claim 14 is rejected under the same rationale as claim 3.

As per claim 15, the G. Celentano et al. reference discloses the PID parameters or tuning constants are obtained such that (1) the maximum real part of all poles of the continuous-time closed-loop transfer-function from said SP to said PV is minimized, possibly subject to any user specified constraints on the PID parameters or tuning constants, such as some or all of elements in the PID parameters or tuning constants should be within user specified ranges, where the said PID parameters or tuning constants can be matrices or scalars (see page 7, "... minimize some quality index of the closed loop control system. ... confine ... the roots of the polynomial ... closed loop system poles, in some desired region of the complex plane ..."), or (2) the maximum magnitude of some or all elements in the PID parameters or tuning constants is minimized, subject to the constraint that the maximum real part of all poles of the said continuous-time closed-loop transfer function from said SP to said PV is not larger than a user specified number.

Conclusion

15. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

The following patents are cited to further show the state of the art with respect to optimization of PID controllers in general:

USPN 6,510,353 B1 to Gudaz et al.

USPN 6,434,436 B1 to Adamy et al.

USPN 5,866,861 to Rajamani et al.

USPN 5,680,304 to Wang et al.

USPN 4,539,633 to Shigemasa et al.

M. Saeki, "A New Adaptive Identification Method of Critical Loop Gain for Multi-Input Multi-Output Plants", Proceedings of the 37th IEEE Conference on Decision and Control, Vol. 4, 16-18 Dec. 1998, Pages 3984 -3989.

M. Zhuang et al., "PID Controller Design for a TITO System", IEE Proceedings on Control Theory and Applications, Volume 141 Issue 2, March 1994, Pages 111 -120.

R.C. Dorf et al., "Enhanced PID Controller Design", Proceedings of the 1991 IEEE International Conference on Robotics and Automation, Volume 3, 9-11 April 1991, Pages 2624 -2629.

16. An examination of this application reveals that applicant is unfamiliar with patent prosecution procedure. While an inventor may prosecute the application, lack of skill in this field usually acts as a liability in affording the maximum protection for the invention disclosed. Applicant is advised to secure the services of a registered patent attorney or agent to prosecute the application, since the value of a patent is largely dependent upon skilled preparation and prosecution. The Office cannot aid in selecting an attorney or agent.

Applicant is advised of the availability of the publication "Attorneys and Agents Registered to Practice Before the U.S. Patent and Trademark Office." This publication is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Crystal J. Barnes whose telephone number is

703.306.5448. The examiner can normally be reached on Monday-Friday alternate Mondays off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Anil Khatri can be reached on 703.305.0282. The fax phone number for the organization where this application or proceeding is assigned is (703) 872-9306.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703.305.3900.

cjb
November 3, 2003

ANIL KHATRI
SUPERVISORY PATENT EXAMINER